Software Development for Aviex CCD Detectors

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Introduction

We have developed a toolkit for low-level control of area detectors.

It has been used with the following detectors from Aviex LLC:

PCCD-170170 - 4096 x 4096 in-vacuum CCD detector currently used at Synchrotron SOLEIL.

PCCD-16080 - 4168 x 2084 CCD detector currently used at the Advanced Photon Source.

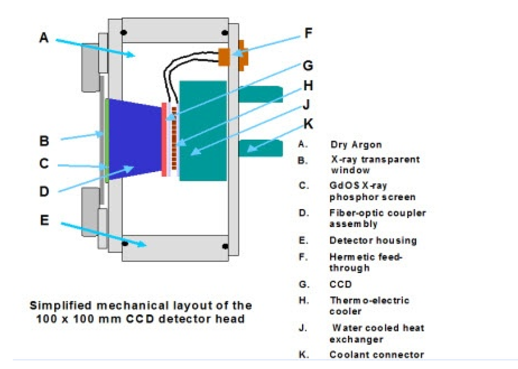
The software is designed to support time-resolved imaging sequences such as for SAXS experiments.

It is based on the MX beamline control toolkit which can be found at http://mx.iit.edu/.

Graphical user interfaces have been developed for Tango-based control systems and MX-based control systems.

Dexela PCCD-170170 CCD Detector

(formerly Aviex)



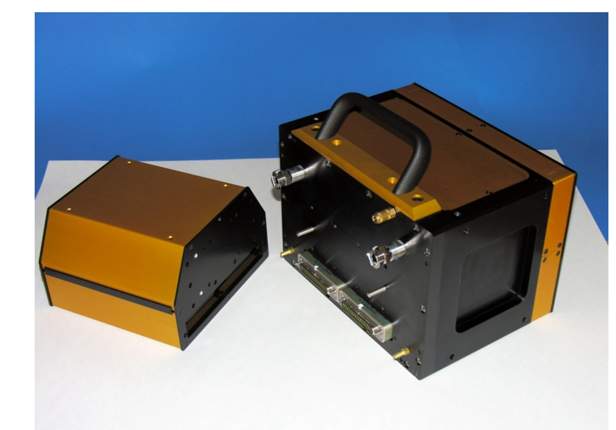
The PCCD-170170 is a large area detector (4096 x 4096) designed for use in WAXS or SAXS experiments *in a vacuum environment.* It is currently available from Dexela LLC.

The detector supports full frame, multiframe time-sliced, and streak camera modes of operation.

Used at the SWING beamline of Synchrotron SOLEIL to make time-resolved SAXS measurements together with another WAXS detector.

It is installed at SWING in a 2 meter diameter, 7 meter long cylindrical vacuum chamber that can be pumped down to 10^{-2} mbar.

Aviex PCCD-16080 CCD Detector

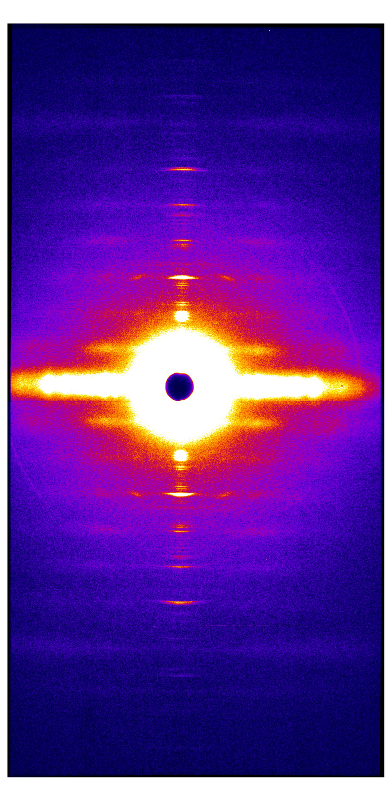


The PCCD-16080 is an older generation CCD detector with a resolution of 4168 x 2084 pixels that is currently in use by BioCAT at the Advanced Photon Source.

Used to perform fiber diffraction and SAXS measurements at BioCAT.

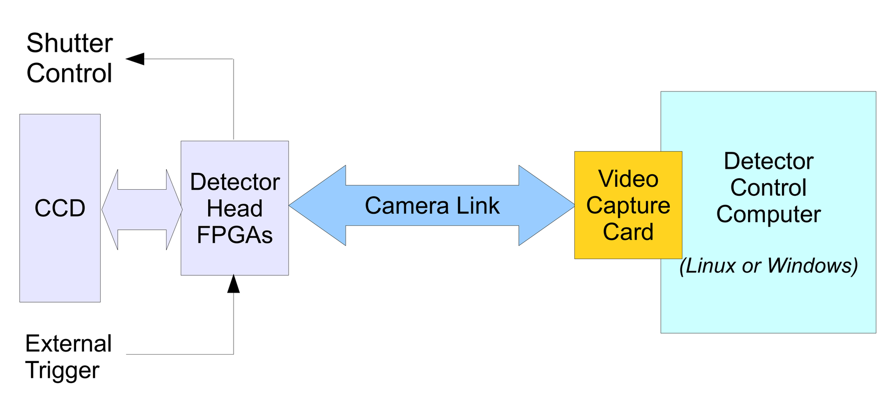
A modification of the software developed for Synchrotron SOLEIL was used to replace an older Delphi-based control system for the detector.

Example Image



This is an example of a mouse skeletal muscle diffraction pattern taken using the PCCD-16080 at BioCAT (APS).

Hardware Block Diagram

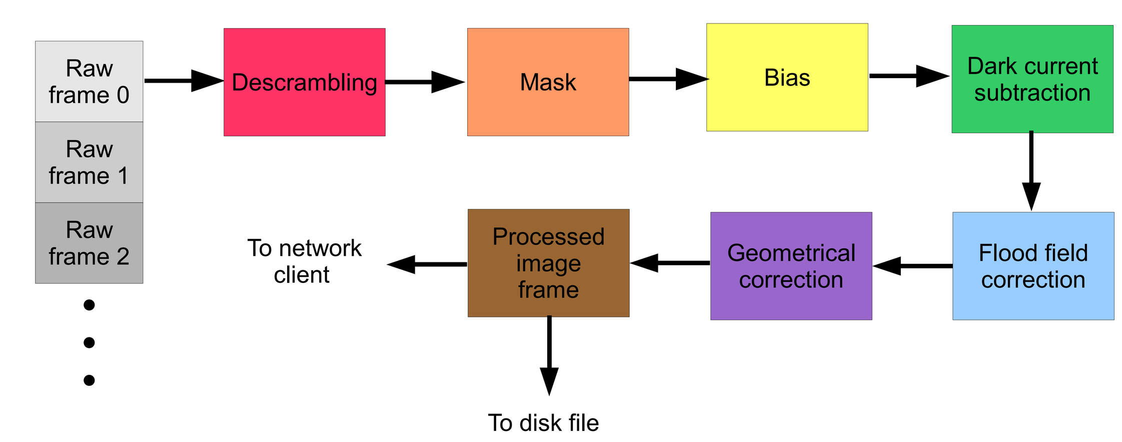


Video Capture Card - PIXCI E4 *(PCI Express / Camera Link)*

Camera Link is an industrial video standard managed by the Automated Imaging Association. The Camera Link cable carries:

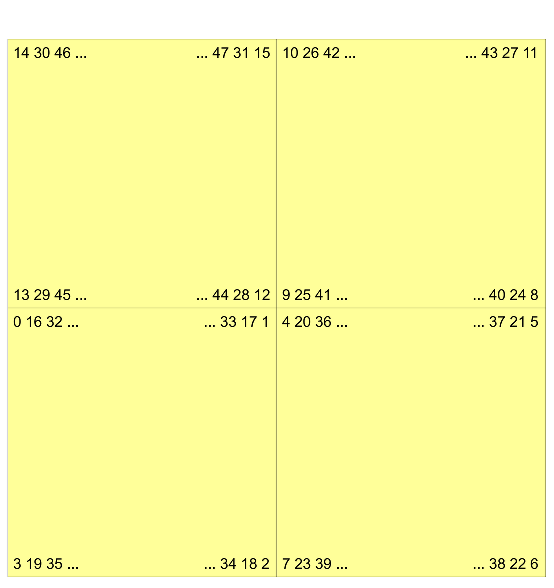
- Binary image data
- ASCII communication with the Detector Head
- Trigger signals for the Detector Head

Image Correction Sequence



Descrambling — Rearrange detector pixels into the correct order for an image.
Mask — Discard known bad pixels.
Bias — Add an offset so that dark current subtraction does not produce negative numbers.
Dark current — Subtract a previously measured background image (dark current) while correcting for exposure time differences.
Flood field — Correct for uneven response to light by the various detector pixels.
Geometrical correction — Correct for geometrical distortions produced during the transport of light from the X-ray phosphor to the surface of the CCD chip.

Descrambling



Raw pixels do not arrive from the detector in the order that they appear in the image.

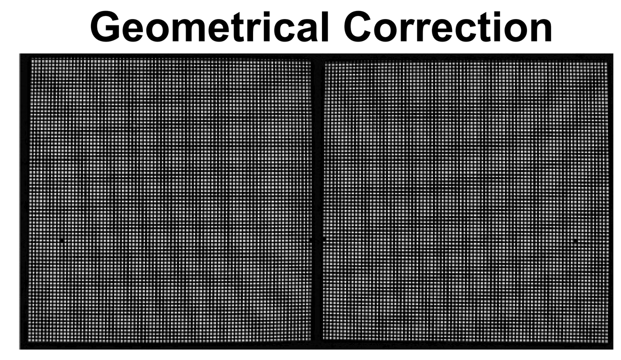
Instead, they appear in the order that they were read from the CCD taps.

This means that they must be *descrambled* into the order that they appear in the image.

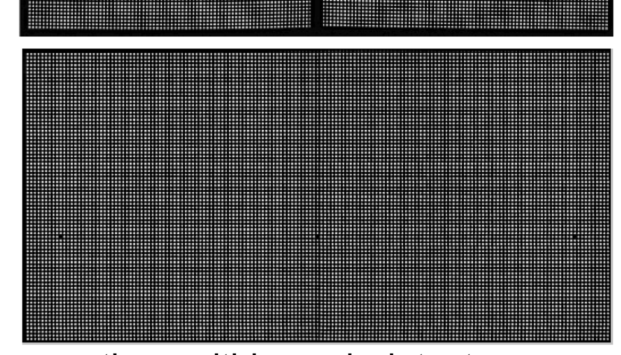
The example above is for the PCCD-170170 detector in full frame mode. The 4 CCD chips have 16 taps altogether (4 at each corner).

If we think about the pixels in groups of 16, then the fourteenth pixel in each group goes to the upper left hand corner, while the sixth pixel goes to the lower right hand corner.

Geometrical Correction



(before)



(after)

Geometrical corrections within each detector segment are made based on a two-dimensional spline derived from a brass-plate exposure of the fully assembled detector array. A smooth transition between the two detector segments is enforced by eliminating from the spline all pixels that are known to be outside the active area of the detector; this elimination is performed by carefully delineating the inactive regions.

The geometrical correction code was written by Andrew Howard of IIT.

Examples of Issues Encountered

Differences of opinion about data correction strategy

Not all scientists agree about how data should be corrected, so you must be prepared to handle different strategies.

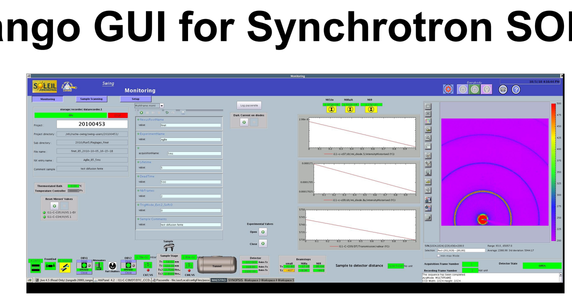
As an example, a bias (typically 200) is generally added to image pixels before dark current subtraction is performed to prevent negative underflows. But some scientists feel that this leads to subtle non-linearities and prefer to add the bias at the end. This requires using signed integers or floating point to handle underflow of the dark correction.

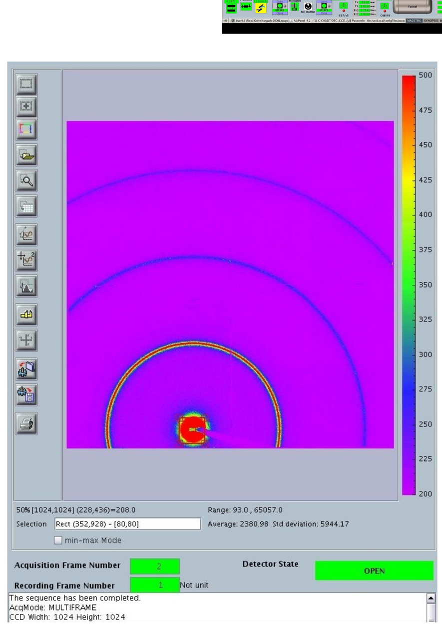
Video capture card vendors that do not understand our needs

One video capture card vendor made it difficult to change video resolutions by requiring the loading of multi-hundred line config files that could only be created in the vendor's GUI. They were eventually persuaded to provide an undocumented way of directly changing the video resolution.

Area detectors have many such issues due to their complexity.

Tango GUI for Synchrotron SOLEIL

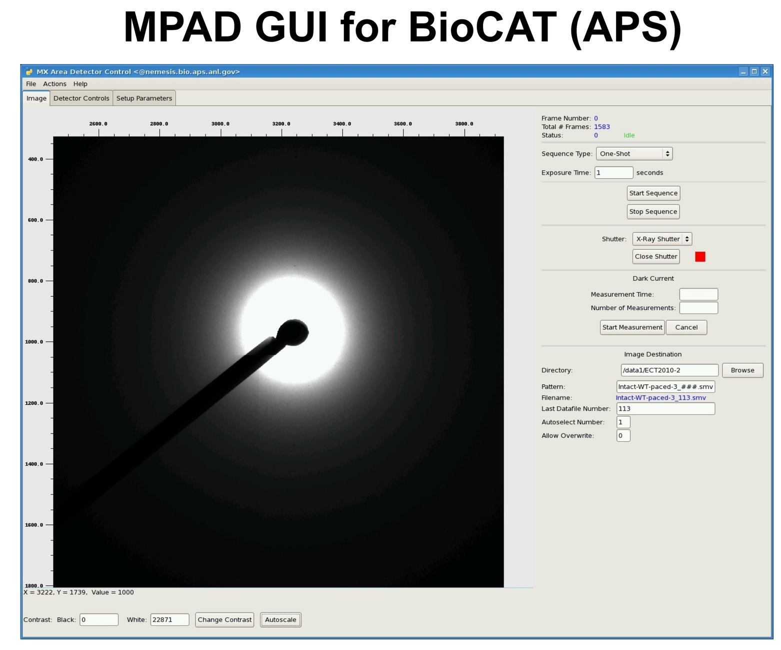




Developed by the SOLEIL Control Software Group.

The GUI uses the ATK package from ESRF to display the image.

MPAD GUI for BioCAT (APS)



The MX-based MPAD GUI is implemented using wxPython, NumPy, and Python Imaging Library.

It was written by William Lavender.

More Information

MX Beamline Control Toolkit http://mx.iit.edu/

Dexela Limited http://www.dexela.com/

SWING at Synchrotron SOLEIL
http://www.synchrotron-soleil.fr/Recherche/LignesLumiere/SWING

BioCAT at the Advanced Photon Source
http://www.bio.aps.anl.gov/

William Lavender http://csrri.iit.edu/~lavender/

IIT Biological, Chemical, and Physical Sciences Department
http://www.iit.edu/csl/bcps/